FORM PTO-1390 (REV. 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY 'S DOCKET NUMBER: 78104.025

U S APPLICATION NO (if known, see 37 CFR 1 5): 09/857229

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/GB99/04064	3 December 1999	3 December 1998

TITLE OF INVENTION: PROCESS FOR DEPOSITING CONDUCTING LAYER ON SUBSTRATE

APPLICANT(S) FOR DO/EO/US: RAMSEY, John Blue; LOCHUN, Darren; HARRISON, David

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [ ] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [X] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is attached hereto (required only if not communicated by the International Bureau).
   b. [XX] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [ ] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [X] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [XX] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). (UNSIGNED)
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [X] Other items or information: Copy of International Preliminary Examination Report

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
09/857229		

21. [X] The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1000.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$860.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$690.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [X] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ 130.00	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	19 - 20 =	0	x **$18.00**	$ 0.00
Independent claims	2 - 3 =	0	x **$80.00**	$ 0.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$270.00**	$ 0.00
TOTAL OF ABOVE CALCULATIONS =				$ 990.00
[X] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.			+	$ 495.00
SUBTOTAL =				$ 495.00
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$ 0.00
TOTAL NATIONAL FEE =				$ 495.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 0.00
TOTAL FEES ENCLOSED =				$ 495.00
			Amount to be refunded:	$
			charged:	$

a. [X] A check in the amount of $ 495.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [XX] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 18-2055 . A duplicate copy of this sheet is enclosed.

d. [ ] Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:
Craig A. Fieschko
DeWitt Ross & Stevens S.C.
8000 Excelsior Drive, Suite 401
Madison, WI 53717-1914

SIGNATURE

Craig A. Fieschko
NAME

39,668
REGISTRATION NUMBER

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): RAMSEY et al. Atty. Docket: 78104.025
Title: PROCESS FOR DEPOSITING CONDUCTING LAYER ON SUBSTRATE

PRELIMINARY AMENDMENT (37 CFR §1.121/MPEP 714.09)

Box: PCT
Assistant Commissioner for Patents
Washington, D.C. 20231

To the Commissioner:

Prior to calculation of the filing fee and examination of the above-referenced application on the merits, please amend its claims as follows:

AMENDMENTS

In the Specification (37 CFR §1.121(b)):

Please insert the following paragraph between lines 1-2 at page 1 of the specification.

- FIELD OF THE INVENTION -

Please insert the following paragraph between lines 5-6 at page 1 of the specification.

- BACKGROUND OF THE INVENTION -

Please insert the following paragraph between lines 27-28 at page 2 of the specification.

- SUMMARY OF THE INVENTION -

Please insert the following paragraph between lines 5-6 at page 7 of the specification.

- DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION-

I certify that this correspondence is being deposited with the United States Postal Service as Express Mail - Post Office to Addressee, in an envelope addressed to: Box: PCT, Assistant Commissioner for Patents, Washington, D.C. 20231.

EL800008978US 01 June 2001 [signature]
Express Mail Label No. Date of Deposit Signature

In the Claims (37 CFR §1.121(c)):

Please cancel claims 3-18 without prejudice to further prosecution of these claims in one or more continuing applications.

Please add new claims 19-35 as set forth in the following pages.

19. **[NEW]** The process of claim 2 further comprising the step of attaching an electrical component to the first or second conducting layer by means of a conductive polymer adhesive.

20. **[NEW]** The process of claim 1 wherein the substrate is formed from a polymer into a flexible sheet.

21. **[NEW]** The process of claim 1 wherein the substrate is coated with a copolymer adhesive.

22. **[NEW]** The process of claim 1 wherein the ink comprises a particulate material suspended in a mixture of a resin and an organic solvent.

23. **[NEW]** The process of claim 22 wherein the particulate material is a metal or carbon.

24. **[NEW]** The process of claim 22 wherein the resin is a polymer having amide groups.

25. **[NEW]** The process of claim 1 wherein the thickness of the seeding layer is from 3 to 5 microns.

26. **[NEW]** The process of claim 1 wherein the thickness of the first electrically conducting layer is less than or equal to 4 microns.

27. **[NEW]** The process of claim 1 wherein the thickness of the first electrically conducting layer is about 0.25 microns.

28. **[NEW]** The process of claim 1 wherein the first electrically conducting layer is formed from at least one of copper, palladium, silver, gold, platinum, and nickel.

29. **[NEW]** The process of claim 1 further comprising the step of soldering an electrical component on the substrate.

30. **[NEW]** The process of claim 1 further comprising the step of attaching an electrical component to the first conducting layer by means of a conductive polymer adhesive.

31. **[NEW]** An electrical assembly comprising a substrate having at least one electrically conducting layer, which layer has been formed by the process of claim 1.

32. **[NEW]** An interconnect for a battery, the interconnect being formed by the process of claim 1.

33. **[NEW]** A battery containing the interconnect of claim 32.

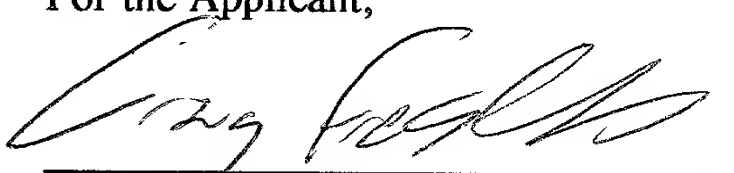
34. **[NEW]** A lithographic ink for use in a lithographic printing process onto a polymer substrate, the ink comprising a particulate material suspended in a mixture of a resin and an organic solvent, wherein the resin comprises a polyamide.

35. **[NEW]** An ink as claimed in claim 34 wherein the particulate material is a metal or carbon.

REMARKS

Claims 19-35 are submitted as replacements to claims 3-18 to remove multiple dependencies. No new matter has been added to the application by these amendments, and the application is now ready for examination on the merits. If any questions regarding the application arise, please contact the undersigned attorney. Telephone calls related to this application are welcomed and encouraged. The Commissioner is authorized to charge any fees or credit any overpayments relating to this application to deposit account number 18-2055.

For the Applicant,



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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): RAMSEY et al. Atty. Docket: 78104.025
Title: PROCESS FOR DEPOSITING CONDUCTING LAYER ON SUBSTRATE

AMENDMENT SHEET ("MARKED-UP" COPY) SHOWING CHANGES TO APPLICATION (37 CFR §§1.121(b)(1)(iii); (c)(i)(ii))

(To Accompany Preliminary Amendment)

In accordance with 37 CFR §§1.121(b)(iii) and (c)(ii), following are the amendments made to the specification and/or claims of the above-noted application.

- All deletions are indicated by brackets **[like so]** and all additions are indicated by underlining <u>like so</u>.
- The additions and deletions are made with respect to the application as it is understood to exist prior to entry of this amendment (i.e., any amendments are made with respect to the previous version).
- While 37 CFR §§1.121(b)(1)(iii) and (c)(1)(ii) does not require that new and canceled paragraphs and claims be supplied on this "marked-up" copy, such new additions and cancellations are nevertheless provided below to aid the reviewer's understanding.

<u>IN THE SPECIFICATION:</u>

The following paragraph is added between lines 1-2 at page 1 of the specification.

- FIELD OF THE INVENTION -

The following paragraph is added between lines 5-6 at page 1 of the specification.

- BACKGROUND OF THE INVENTION -

The following paragraph is added between lines 27-28 at page 2 of the specification.

- SUMMARY OF THE INVENTION -

The following paragraph is added between lines 5-6 at page 7 of the specification.

- DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION-

<u>IN THE CLAIMS:</u>

Claims 3-18 are canceled without prejudice to further prosecution of these claims in one or more continuing applications.

Claims 19-35 are added as follows:

19. **[NEW]** The process of claim 2 further comprising the step of attaching an electrical component to the first or second conducting layer by means of a conductive polymer adhesive.

20. **[NEW]** The process of claim 1 wherein the substrate is formed from a polymer into a flexible sheet.

21. **[NEW]** The process of claim 1 wherein the substrate is coated with a copolymer adhesive.

22. **[NEW]** The process of claim 1 wherein the ink comprises a particulate material suspended in a mixture of a resin and an organic solvent.

23. **[NEW]** The process of claim 22 wherein the particulate material is a metal or carbon.

24. **[NEW]** The process of claim 22 wherein the resin is a polymer having amide groups.

25. **[NEW]** The process of claim 1 wherein the thickness of the seeding layer is from 3 to 5 microns.

26. **[NEW]** The process of claim 1 wherein the thickness of the first electrically conducting layer is less than or equal to 4 microns.

27. **[NEW]** The process of claim 1 wherein the thickness of the first electrically conducting layer is about 0.25 microns.

28. **[NEW]** The process of claim 1 wherein the first electrically conducting layer is formed from at least one of copper, palladium, silver, gold, platinum, and nickel.

29. **[NEW]** The process of claim 1 further comprising the step of soldering an electrical component on the substrate.

30. **[NEW]** The process of claim 1 further comprising the step of attaching an electrical component to the first conducting layer by means of a conductive polymer adhesive.

31. **[NEW]** An electrical assembly comprising a substrate having at least one electrically conducting layer, which layer has been formed by the process of claim 1.

32. **[NEW]** An interconnect for a battery, the interconnect being formed by the process of claim 1.

33. **[NEW]** A battery containing the interconnect of claim 32.

34. **[NEW]** A lithographic ink for use in a lithographic printing process onto a polymer substrate, the ink comprising a particulate material suspended in a mixture of a resin and an organic solvent, wherein the resin comprises a polyamide.

35. **[NEW]** An ink as claimed in claim 34 wherein the particulate material is a metal or carbon.

PROCESS FOR DEPOSITING CONDUCTING LAYER ON SUBSTRATE

The present invention relates to a process for forming an electrically conductive layer on a substrate, and in particular to a process for forming such a layer on a substrate which can be used as a circuit board in an electrical assembly.

Conventionally, silicon devices are mounted on printed circuit boards (PCB). A printed circuit board generally consists of etched copper on glass fiber laminate, tin plated and possibly carrying further layers of lacquer for protection and labeling. Many operations of cropping, drilling, etching and plating are involved in its preparation. It is not cheap, and the production processes can have significant environmental impact.

The two major environment hazards posed by PCB manufacture are the waste effluent which is acidic and contains heavy metals (especially copper), and the use of hydrocarbons in photoresist developer and stripper. Stricter pollution limits imposed by water authorities are one driving force to reduce copper in effluent. In theory, waste effluent could be eliminated by a totally additive process for copper deposition, which would also offer considerable cost savings, but a satisfactory process has not yet been developed.

Attempts to avoid the use of a circuit board as such include the use of both thick and thin film techniques, normally associated with higher cost, not lower. Resistors are formed on a ceramic substrate by depositing tracks of a suitable film, sometimes trimmed to precise values by laser etching. A film of higher conductivity is generally used for interconnection.

WO 97/48257, which has common applicants with the present application, the disclosure of which is incorporated herein, discloses an alternative method of forming an electrical circuit board, whereby a conducting ink is lithographically printed onto a substrate in order to form an electrical circuit. The ink comprises electrically

conductive particles (such as metallic silver) suspended in an organic resin such as an alkyd resin. The manufacture of electrical components such as resistors, capacitors and antennae is also described.

Although the circuit printing technique disclosed in WO 97/48257 is a significant improvement on previous techniques, it has a number of disadvantages.

First, it is advantageous to electroplate a second conducting layer onto the conductive ink disclosed in WO 97/48257 in order that electrical components can then be soldered on to the substrate and/or to reduce the resistivity of the circuit. The problem is that the ink does not adhere sufficiently well to the substrate to enable electroplating.

Second, in order to prepare a conductive ink, it is necessary to employ particulate conductive material with a particulate surface treatment (e.g. a coating of a long chain fatty acid) to enable the particles to be dispersed in the resin in such a manner as to render the dried ink electrically conductive. However, this surface treatment precludes further treatment of the dried ink, for example it prevents deposition of a further conductive layer by electroless deposition.

Third, it is difficult to solder electrical components onto an electrical circuit formed from conductive ink layers, because the layers do not contain sufficiently a high metal loading to create a suitable solder join. This means that components must be affixed using conductive polymer adhesive or a mechanical joint. However, it is thought that these joining methods do not age as well as solder, and exhibit higher electrical resistance. Moreover, any increase in the content of conductive particles in the ink is to the detriment of the ink's rheological properties.

According to a first aspect of the present invention, there is provided a process for forming a conductive layer on the substrate, comprising the steps of depositing ink on

the substrate by means of lithographic printing to form a seeding layer, and depositing a first electrically conducting layer on the seeding layer by electroless deposition.

Electroless deposition (or plating) is a well-known technique which involves coating an object (or part of an object) by means of a chemical reduction process, which, once initiated, is also-catalytic. The process is similar to electroplating except that no external current is required. In order to electroless plate an object, a seeding layer of suitable geometry and electrical and chemical characteristics must be formed on the object in order to provide nucleation sites for the metal to be deposited. It is thought that the seeding layer acts as a catalyst, in that it reduces the activation energy for the deposition step.

The term "lithographic printing" referred to herein is a printing process which utilizes differences in surface chemistry of the printing plate, including hydrophilic and hydrophobic properties. It does not refer to the commonly used process involving photoresist and etching occurring during the production of etched circuit boards and/or silicon semiconductor micro electronics. The term "ink" is intended to mean any material suitable for printing.

The ink which is employed in the present invention preferably comprises a particulate material suspended in a mixture of a resin and an organic solvent. Most preferably, the particulate material is particulate metal or carbon. Particularly suitable materials include silver, gold, copper, zinc or nickel. The particle size may be from 0.1 to 10 micrometers, and preferably from 0.25 to 1 micrometers, more preferably greater than 0.1 micrometers and less than (but not equal to) 1 micrometer, and most preferably from 0.25 to 0.75 micrometers.

The amount of the particulate material in the ink is preferably from 50 to 90% w/w, and most preferably about 75% w/w.

The resin for use in the ink may be a polymer blended with various oils. Preferably, the resin comprises a polymer having amide groups, for example a nylon-based polymer.

One resin which has been found to be particularly suitable is available commercially Lawter International (of Ketenislaan 1c-Haven 1520, B-9130 Kallow, Belgium) under the trade name "Nypol 3". Nypol 3 comprises a modified polyamide and tung oil and vegetable oil blends.

Other resins which have exhibited acceptable performance include phenolic modified resin and alkyd resins, which are blended with modified mineral oils and vegetable oils.

In order to form the ink, the resin is mixed with a solvent and a suspension of the particulate material is formed. The solvent (or diluent) can be any suitable organic solvent with a boiling point of about 250°C.

The substrate onto which the conductive layer is printed is preferably formed from a polymer, and preferably comprises a flexible sheet. Suitable polymers include polyethylene, polypropylene, a polyester, a polyamide, a polyimide or a polysulphone. The substrate may be treated to improve adhesion of the ink to the substrate surface. For example, the substrate may be coated with a copolymer adhesive layer, or the surface may be chemically treated or subjected to corona treatment.

Preferably, the substrate is formed from a polyester, polyethylene, polypropylene or a polyamide, with or without a copolymer adhesive layer. In a particularly preferred embodiment, the substrate is a copolymer coated polyester, such as that available commercially from GBC (UK) Ltd of Rutherford Road, Basingstoke, Hampshire, RG24 8PD.

It has been discovered that modified polyamide resins work acceptably well with substrates formed from polyethylene, polypropylene, polyamide and polysulphone. Modified phenolic resins work acceptably well with polyester, polyimide or polysulphone substrates. Alkyd resins adhere reasonable well to polyester substrates.

As described above, the ink is deposited onto a substrate by means of a lithographic printing process in order to form a seeding layer for electroless deposition. The thickness of the seeding layer in the present invention is preferably from 3 to 5 micrometers.

Electroless deposition of a first electrically conductive layer is carried out by conventional means. The conducting layer may be formed from any suitable electrically conductive material which can be deposited by electroless deposition, for example copper, silver, nickel or gold.

The thickness of the first conducting layer may be up to 4 micrometers and is preferably about 1 micrometer (although the thickness will be determined by the required electrical specifications).

The process of the present invention may comprise the step of electroplating a second electrically conducting layer onto the first conducting layer.

Electroplating is a well-known method whereby an object or part of an object is coated by means of electrolytic deposition. In order to be electroplated, the object has to have an electrode which exhibits a suitable geometry and electrical and chemical characteristics. In the case of the present invention, the first conducting layer which is deposited on the seed layer acts as an electrode in the electroplating process, thereby enabling the second conducting layer to be electrolytically deposited onto the first conducting layer.

The addition of a second conducting layer improves the conductivity of the circuit tracks and improves the soldering of electrical components directly onto the substrate in order to form electrical assemblies (components may be soldered directly onto the first conducting layer).

If a second layer is going to be electroplated onto the first, then the first layer does not need to be as much as 1 micrometer thick; a thickness which render the substrate conductive is required, for example from 0.25 to 0.5 μm.

As with the first conducting layer, the second layer may comprise any suitable electrically conducting material which can be electroplated. The thickness of the second conducting layer may be anything up to 35 micrometers, depending on the required specification of the circuit board.

Although a conducting layer can be electroplated onto an electrical circuit prepared according to the process disclosed in WO 97/48257, the resulting circuit board is structurally unstable due to the poor adhesion of the conducting ink onto the substrate.

By contrast, an electrical component can be soldered directly onto an electrical circuit prepared by the present method, particularly if a second conducting layer is deposited by means of the electroplating step, since by this step sufficient conducting layer can be deposited to which a good solder link can be formed.

One example application of the present invention is in the manufacture of electronic circuit boards. The lithographically deposited seeding layer is printed in the graphical configuration of an electrical or electronic circuit. The seeding layer can then be electrolessly plated with copper and a further layer of tin or other protective layer. These layers improve the conductivity of the circuit tracks and allow them to be soldered directly onto via existing solder technologies.

The lithographic process of production of seeding layers offers advantages of speed of production and very fine track and gap width resolution.

An embodiment of the present invention is below, by way of illustration only. For ease of understanding, the embodiment is described by way of its component parts.

The ink

Ink layers deposited by the preferred lithographic printing process are about 5 micrometers (5×10^{-6}m) thick. This may be compared to about 25 micrometers for conductive layers deposited by screen printing, and 20-75 micrometers of copper typically laminated onto a conventional printed circuit board.

The adopted approach has been to formulate an ink from particles suspended in an organic resin. Manipulation of the resin formulation permits a degree of control over certain mechanical characteristics of the ink (e.g. viscosity).

As described above, the particulate material should be such as to enable the electroless deposition step. Suitable materials include silver, copper, carbon and palladium.

Hydrocarbon solvents and other suitable additives are used to adjust the printing, wear resistance and drying properties of the printed layer. An antioxidant (such as eugenol) is preferably incorporated to react with free radicals and thereby prevent auto-oxidation of the resin. In other words, the antioxidant prevents the resin from drying too quickly.

A drying agent such as a cobalt salt can be included to dry the resin once the antioxidant is used up.

An example of a preferred formulation of an ink is:

Component	Identity	Amount
Particulate	Silver particles with a mean particle size of 1 micrometer	about 75% w/w
Resin	Nylon based hydrocarbon	about 23% w/w
Solvent	Medium to high boiling point organic	about 2% w/w
Drying agent	Cobalt salt	trace
Antioxidant	Eugenol	trace

The resulting ink formulation exhibits Newtonian properties, exhibiting a viscosity of about 5^4 to 10^4mPaS @ 25 degrees C. Suitable viscosities of ink formulations are considered to lie in the range 10^3mPaS @ 25 degrees C to 10^5mPaS @ 25°C.

The substrate

The copolymer-coated polyester from GBC (UK) Ltd was used.

Printing process

First, the required artwork (that is, the pattern which is to become the electrical circuit) is applied to an anodised aluminium plate using the standard photoresist method used in the lithographic printing process. Second, the aluminium plate is used as a template in a lithographic process to apply the ink to the substrate in the required artwork pattern.

Electroless plating

The electroless process involves placing the inked substrate in an electroless bath (such as the bath supplied by Shipley Ronal Limited) which contains a commercially available electroless plating solution. This comprises a solution of a copper salt (such as copper sulphate); a chelating agent e.g. EDTA; stabilisers such as sulphur compounds or heavy metals; an aqueous alkaline solution, for example aqueous

sodium hydroxide; a reducing agent for example formaldehyde; and, optionally, a surfactant. This is known under the trade mark "CP78 process".

Typical deposition rates achievable by use of this commercial process are approximately 4 micrometers of metal per hour. Typically therefore for a 1 micrometer layer, the substrate is placed in the electroless bath for ten to fifteen minutes.

As mentioned above, if the substrate is subsequently to be electroplated, then it is not necessary to electroless deposit a 1 micrometer layer. A sufficiently thick layer to act as an electrode in the electroplating process will result from placing the substrate in the electroless bath for about three to seven minutes.

Electroplating process

Electroplating processes are well known in the art. For example, copper sulphate solution is used as the electrolyte. The rate of copper deposition is dependent upon the surface area of the cathode and the current density. A typical current density is 25 Amps per square decametre. The anode is copper and the cathode is the item to be plated (i.e. the conductive tracks).

Manufacture of electrical circuit board

As described above, electrical components can be soldered directly onto the conductive layers on substrate formed by the above processes. Alternatively, a conductive polymer adhesive can be used such as an epoxy adhesive.

The present process can be employed to form a variety of devices comprising electrical circuitry. Examples of electrical assemblies which can be created using the above processes include battery interconnect circuitry, microwave integrated circuits,

antennae, such as microwave antennae, planar antennae or contoured antennae structures.

In a further aspect of the present invention, there is provided a method of depositing an electrically conducting layer onto a conducting layer of a substrate prepared by the method disclosed in WO 97/48257 by means of electroplating, electroless deposition, or a combination thereof.

The disclosures in UK patent application numbers GB 9826446.8 and GB9826447.6, from which this application claims priority, and in the abstract accompanying this application, are incorporated herein by reference.

CLAIMS

1. A process for forming a conductive layer on a substrate, comprising the steps of depositing ink on the substrate by means of lithographic printing to form a seeding layer, and depositing a first electrically conducting layer on the seeding layer by electroless deposition.

2. A process as claimed in claim 1, comprising the step of electroplating a second electrically conducting layer onto the first electrically conducting layer.

3. A process as claimed in any preceding claim, wherein the substrate is formed from a polymer into a flexible sheet.

4. A process as claimed in any preceding claim, wherein the substrate is coated with a copolymer adhesive.

5. A process as claimed in any preceding claim, wherein the ink comprises a particulate material suspended in a mixture of a resin and an organic solvent.

6. A process as claimed in claim 5, wherein said material is a metal or carbon.

7. A process as claimed in claim 5 or 6, wherein the resin is a polymer having amide groups.

8. A process as claimed in any preceding claim, wherein the thickness of the seeding layer is from 3 to 5μm.

9. A process as claimed in any preceding claim, wherein the thickness of the first electrically conducting layer is up to 4μm.

10. A process as claimed in any preceding claim, wherein the thickness of the first electrically conducting layer is about 0.25μm.

11. A process as claimed in any preceding claim, wherein the first electrically conducting layer is formed from copper, palladium, silver, gold, platinum, nickel.

12. A process as claimed in any preceding claim, including the step of soldering an electrical component on the substrate.

13. A process as claimed in any of claims 1 to 11, including the step of attaching an electrical component to the first or second conducting layer by means of a conductive polymer adhesive.

14. A electrical assembly comprising a substrate having at least one electrically conducting layer, which layer has been formed by a process as claimed in any of claims 1 to 13.

15. A lithographic ink for use in a lithographic printing process onto a polymer substrate, the ink comprising a particulate material suspended in a mixture of a resin and an organic solvent, wherein the resin comprises a polyamide.

16. An ink as claimed in claim 15, wherein said material is a metal or carbon.

17. An interconnect for a battery which is formed by a process as claimed in any of claims 1 to 13.

18. A battery including an interconnect as claimed in claim 17.

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): LOCHUN, et al. Atty. Docket: 78104.025
Title: PROCESS FOR DEPOSITING CONDUCTING LAYER ON SUBSTRATE

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

Each undersigned inventor hereby declare(s) that:

- My residence, post office address and citizenship are as stated below next to my name.
- I believe that I am, in conjunction with any joint inventor(s) named herein, the original and first inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **PROCESS FOR DEPOSITING CONDUCTING LAYER ON SUBSTRATE**, the patent application for which was filed as PCT international application number PCT/GB99/04064 on 03 December 1999, and which is amended by a preliminary amendment filed with this document.
- I reviewed and understand the contents of the above-identified patent application, including the specification and claims, as amended by any amendments referred to above.
- I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability, as defined in Section 1.56 of Title 37, U.S. Code of Federal Regulations.
- Foreign priority benefits are claimed under Title 35, U.S. Code §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designated at least one country other than the United States of America, listed below. Also identified below are any foreign applications for patent or inventor's certificate, or any PCT international application having a filing date before that of the application for which priority is claimed.

Application No.	*Country*	*Day/Month/Year*	*Priority Claimed*
PCT/GB99/04064	**PCT**	**03/12/99**	**Yes**
9826446.8	**Great Britain**	**03/12/98**	**Yes**
9826447.6	**Great Britain**	**03/12/98**	**Yes**

I APPOINT the following registered practitioner(s) to prosecute this application and to transact all related business in the U.S. Patent and Trademark Office: Craig A. Fieschko (39,668), Joseph T. Leone (37,170), Charles S. Sara (30,492).

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I DECLARE THAT all statements made herein of my own knowledge are true; all statements made on information and belief are believed to be true; that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 USC §1001; and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signature

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